RIGHT WHALE SIGHTINGS AND SURVEY EFFORT IN THE MID ATLANTIC REGION: MIGRATORY CORRIDOR, TIME FRAME, AND PROXIMITY TO PORT ENTRANCES

A report submitted to the NMFS ship strike working group

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INTRODUCTION

North Atlantic right whale (Eubalaena glacialis) movements in the mid Atlantic region of the United States are not well understood. Right whales are known to seasonally utilize five high use habitats along the eastern seaboard – four of these habitats are in the northern feeding grounds off the New England and Maritime Canada coasts and the fifth is in the southeast US. The mid Atlantic has been identified as a migratory corridor between the calving ground and feeding grounds to the north. The time frame that animals utilize the mid Atlantic waters and the extent of usage has been only modestly referred to in literature when describing the shore based whaling industries that once existed off the North Carolina and Long Island coasts. Information from tagged individual right whales has shed further light on the migratory corridor. However analysis of all existing sightings and effort data, sparse as it is, has not been undertaken.

The right whale mortality data indicate that of 53 documented mortalities between 1970 and 2002, 14 (26%) have occurred in mid Atlantic waters. Five of these have been attributed to ship strikes which represents 28% of all documented ship strike mortalities (n=18). The need for information regarding right whale usage of the mid Atlantic has important implications for the possible management of vessel traffic to prevent ship strikes with right whales.

The purpose of this report is to visually display sightings and survey effort on a month by month basis for all years combined and to analyze distance from shore and water depth of sightings. These analyses may allow for a clearer description of the extent and duration of the migratory corridor. Plots of right whale sighting activity in relation to port entrances are also provided. For this report, the mid Atlantic has been defined as the Georgia/South Carolina border north to latitude 41°20’N and west of 69°45’W which encompasses the waters off of southern New England (not including the Great South Channel). The southern extent of the study area also includes the area off the coast of Georgia north of the existing critical habitat at 31°15’N.

This report is intended for the use of the NMFS Ship Strike Working Group only. Since these plots include data generated by several groups and agencies each of whom retain the rights of first publication on their data, we will be working with those data contributors to develop this into a publishable, peer-reviewed paper. We also intend to mesh the findings of this work with a complementary project presently underway by Russell Leaper of IFAW which is modeling departure time of animals from the southeast calving grounds.

The primary questions focused on in creating these plots are as follows:

- **What level of survey effort has been carried out in the mid Atlantic?** Unlike the feeding grounds in the Gulf of Maine and the calving ground off the southeast U.S., survey effort in the mid Atlantic has not been extensive. However, it is valuable to compare the extent of the effort where it exists to explore the issue of nearshore sighting bias which might occur if only opportunistic sightings were used.

- **Can we define the migratory corridor?** By measuring distance from shore of each sighting, we can better describe the corridor used by migrating animals. By reviewing satellite tag data points, and sightings associated with effort, the extent of the corridor may be evident.

- **Are there time frames of migration that can be well defined?** By plotting all sightings for each month, the migration time frame can be explored.

- **Is it reasonable to place buffer zones around port entrances within which management measures could/would be proposed? What would be an appropriate buffer radius to capture the majority of right whale movement in and around each port entrance?** Buffer zones of radii of 20, 30, and 40 nm from a point at the center of harbor entrances were used for comparative purposes

- **Do analyses of distance from shore and water depth at each sighting provide consistent parameters that could be used as recommended measures for transiting ships?** Ships not entering in to port could be provided with information on the migratory corridor with distance from shore and/or water depth extent of migrating animals.

METHODS

<u>Data sources</u>

Several different data sources were utilized for this project including the right whale consortium "database" and "catalog" (further described below). In addition, satellite tag data for two females with calves tagged in the calving ground were provided by Chris Slay, New England Aquarium. Satellite tag data of a female with a calf, an adult female and an unknown age male, all tagged in the Bay of Fundy, were provided by Dr. Bruce Mate of Oregon State University. Confirmed right whale sightings collected by marine observers placed on dredges operating at port entrances along the east coast were provided by Coastwise Consulting Inc. Major datasets were also provided by Georgia Department of Natural Resources, University of North Carolina Wilmington, Continental Shelf Associates, Cetacean and Turtle Assessment Program, and NOAA Fisheries (described under 'database'). Opportunistic sightings from a variety of different sources were also included.

The Database

Numerous research organizations have conducted marine mammal surveys and collected data in a systematic fashion. For the survey effort aspect of this project, the data considered suitable were those where latitude/longitudes were collected on a systematic basis throughout the survey as well as at each course change, change in sea state or visibility, and marine animal sighting. Data collected from both aerial and shipboard platforms were utilized. Many of these data sets had previously been incorporated into the Right Whale Consortium database maintained at the University of Rhode Island.

Data sets which have been acquired but have not yet been integrated into this report because time did not allow include:
UNCW 2001 and 2002 effort

The URI dataset of right whale sightings, both opportunistic and on effort, was queried for this region between 31°15’N to 41°20’N and west of 69°45’N. Group size and presence of a calf were noted.

The Catalog
Another data source was the Right Whale Consortium's photo-identification catalog, curated by the New England Aquarium. This data set includes right whale catalog (individual identification) number, age, sex, latitude/longitude, and observer for all photographed right whale sightings collected from both survey efforts and opportunistic (*i.e.*, non-survey) sources. Only sightings that were not already included in the database at URI were included from the catalog. These sightings included all mortalities documented in the region.

Data manipulation/transformation, GIS program

- Tables were appended to one with the following fields: DAY, MONTH, YEAR, LAT (changed to decimal degrees), LONG (changed to decimal degrees),NUM, TYPE (added to original tables to denote type of survey (A=aerial, S = shipboard)), EVENTNO, SIGHTNO, COMMENTS (altered from original to include only codes of interest to this project including y for mother/calf pairs, and mortality comment codes indicating dead calves), CODE (added to original - includes distinction between tag, mortality, off-effort data, number of animals sighted, and m/c pairs), EGNO, and OBS.
- Effort data was received from URI in three separate files – ship based effort, database aerial effort, and GDNR aerial effort. The aerial tables were appended and saved as dbase files. The shipboard table was saved as a dbase file on its own.

- All data tables were saved as text and edited in MSDOS.

- Point coverages were then created for both sightings and effort tables using ArcInfo's Generate command. They were projected into both UTM and Mercator projections.
- Base coverages for this project include bathymetry, coastal coverages of the Eastern seaboard (downloaded from USGS web site http://woodshole.er.usgs.gov), and shipping lane coverages created in ArcInfo.
- All display maps are Mercator projections using a central meridian of 75.5. All data tables derived from these maps (i.e. distance from sighting to shore or line or port entrance) were derived from UTM projections (zone 18).
- The Code field was edited in ArcView to code animal sightings for the following characteristics:
    - Number of animals sighted – 1 animal, 2-5 animals, and 6-10 animal groupings
    - Right whale mortalities – calf versus adult mortalities were coded
    - Satellite tagged right whales – tagged mother and calf pairs versus lone adults were coded
- Once coded the sighting point theme was selected for the code field and colors and symbols used to illustrate the differences between sightings.
- The point theme which included sightings from all years, was queried for a single month and then saved as a shape file. These shape files were then used for the monthly migration maps.
- Effort data were also brought in as a point theme.
    - Using Animal Movement, a line theme was created from the point coverage illustrating tracklines surveyed.
    - The survey data included sightings recorded under standardized acceptable conditions or 'good effort' (sea state Beaufort 4 or below, elevation at least 750 ft, clear visibility, and observers on watch), and sightings recorded when survey conditions did not meet this criteria, 'bad effort'. Good versus bad survey effort were distinguished in the monthly maps as solid and dotted lines respectively.

- A series of four maps was created to illustrate the activity of right whales in and around port entrances along the mid-Atlantic coast. These maps' sightings distinguished by type (i.e coded as described above) for all years and months but contained no survey effort.
- Each port entrance was marked and a 20, 30, and 40 nm buffer was generated around each.
- Using NobelTech software and the ArcView ChartViewer extension, nautical charts of the port entrances were added to give finer detail of water depth and shipping activity. Charts were brought into ArcView as image files in a geographic projection. The view was then projected into a Mercator. False Easting and False Northing were used to align the coastal coverage created in ArcInfo with the nautical chart image. Sighting data and shipping lanes were overlaid onto the charts.

<u>Distance of sighting to shore</u>

- Determination of a sighting's distance to shore was computed using the Animal Movement extension in conjunction with the Spatial Analyst.
- Coastal coverage was downloaded in latitude/longitude vector format from the USGS web site, manipulated in Excel and used to generate a point coverage in ArcInfo.
- The distance between each sighting and every coastal point was determined (in meters) using the Calculate Distance function and the results added to the associated .pat file.
- The data were sorted in Excel to determine which point of land was closest to each sighting and that information recorded.

<u>Distance of sighting to lines between Capes</u>

- Distance to land was calculated differently between Cape Hatteras south to Cape Romain. Because the coastline between these four Capes inverts and because ship traffic does not traditionally follow the inversion of the coast, a line was constructed between each Cape tip and subdivided into five equal parts.

- Distance was then calculated between nearby sightings and said line instead of land.
- Determination of which sightings to include in this calculation was made by selecting any sighting that fell to the East of the line and that was closer to that line than to any point on shore.
- Distance of sightings to each of the five line points was calculated using Animal Movement and the shortest distance to the line was selected.

Port Buffers

- Each port entrance was isolated and either a graphic point assigned to the port entrance or a coverage portraying that entrance was created.
- Each port point was buffered with 20, 30, and 40 nm concentric circles.
- The animals which fell within these buffered areas were isolated and recorded – this information used for management decisions regarding regulation of ship traffic around port entrances

Data Display

Two series of maps were created for this report. Series 1 (Plots 1-6) are monthly plots with two months per page. Series 2 (Plots 7-10) are port entrances with buffers with a nautical chart blowup of each entrance.

Further information and cautions to the reader

Tracklines for aerial and shipboard data have not been differentiated for these plots.

These plots to not differentiate between sightings collected during effort versus sightings collected opportunistically.

RESULTS

When data from all data sources were combined, the resulting dataset equals 489 confirmed right whale sightings between 1974 and 2002. The majority of sightings were documented in the southern extent of the range between St Simons Island, GA and Georgetown, SC where survey effort has been more extensive (see Figure 2).

Distance to shore

The distance from shore of all sightings ranges from <1 to 140 nm. A graph showing all distances from shore broken down into 5 nautical mile (nm) increments shows the majority of sightings are within 0-5 nm of shore with the second highest number of sightings in 5-10 nm from shore (Figure 1). In Table 1, the percentage of total sightings found within each maximum depth increment shows that 94.1% of all sightings are within 30 nm of the coast and well over half the sightings (63.8%) are found within 10 nm of the coast.

Figure 1.

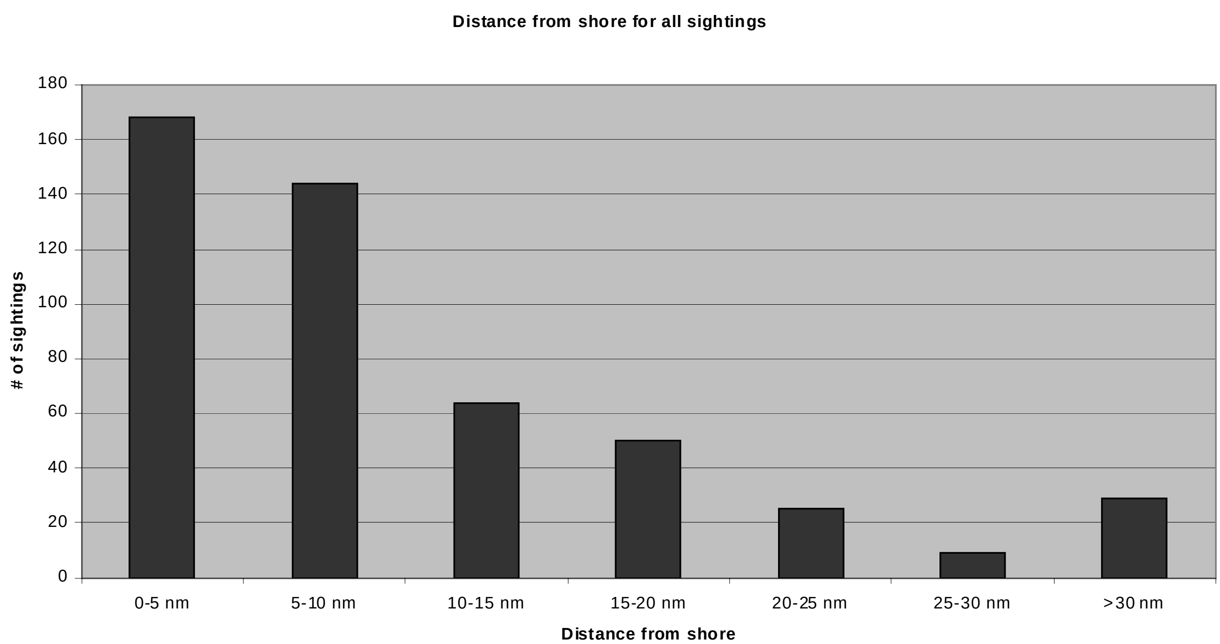
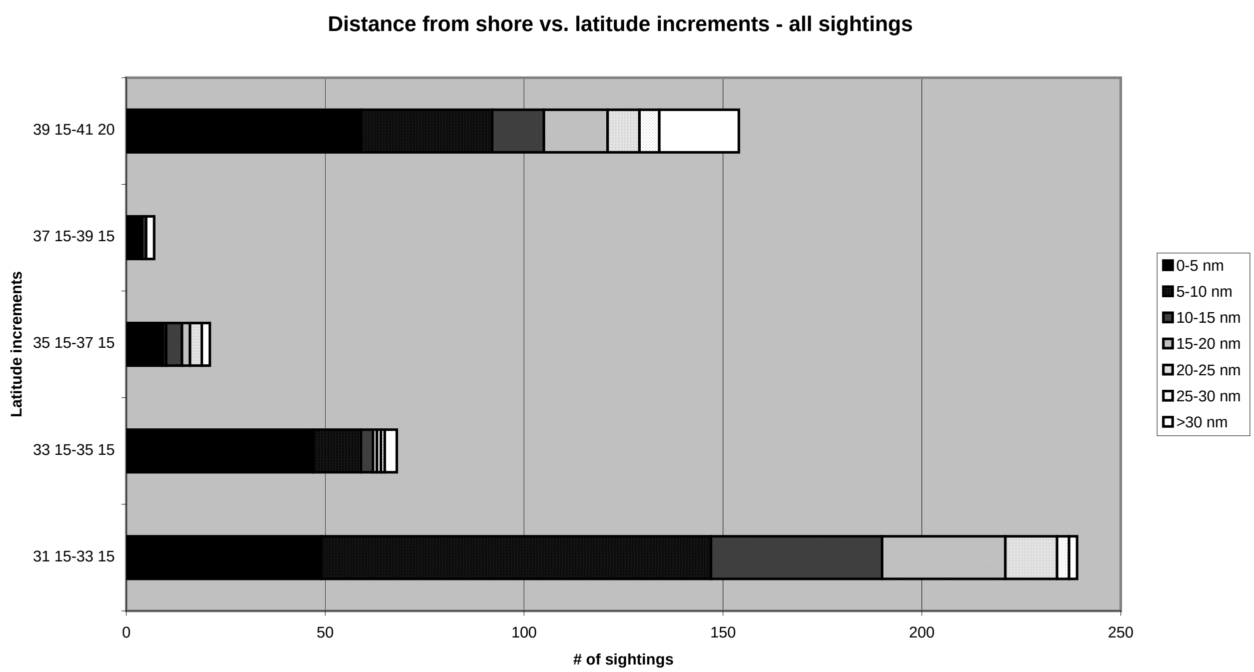

Distance from shore for all sightings
180
160
140
120
100
80
60
40
20
0
# of sightings
0-5 nm
5-10 nm
10-15 nm
15-20 nm
20-25 nm
25-30 nm
>30 nm
Distance from shore

Table 1. Combined distance from shore of all sightings and tagged animal sighting

Nautical miles from land	**% of sightings within this distance (n=489)**	**% of tagged RW sightings within this distance (n=52)**
0 – 5 nm	34.4%	7.7%
0 – 10 nm	63.8%	23.1%
0 – 15 nm	76.9%	38.5%
0 – 20 nm	87.1%	53.8%
0 – 25 nm	92.2%	73.1%
0 – 30 nm	94.1%	80.8%

Figure 2 shows the distance from shore of all sightings broken down in to two degree latitude increments. This graph suggests that the majority of sightings at distances greater than 30 nm from the coast occur at the northern extent of the range (off New York and southern New England). This may be because some animals going around Cape Cod may not follow the coastline. For the remainder of the range, the overwhelming majority of the sightings are within 15 or 20 nm from shore.

Figure 2.



To explore whether some of this nearshore tendency is due to effort bias, the sightings of satellite tagged animals were compared to the total sightings. Figure 3 shows that the 71% (37/52) of the tagged animal sightings were seen in the northern extent of the range with limited numbers of sightings further to the south. However, the data do show a similar pattern in that the majority of sightings beyond 30 nm from shore occur in this northern extent. The pattern further south shows that the nearshore tendency is not as pronounced for these tagged animals, though the majority of sightings still occur within 25 nm miles of the coast.

Figure 3

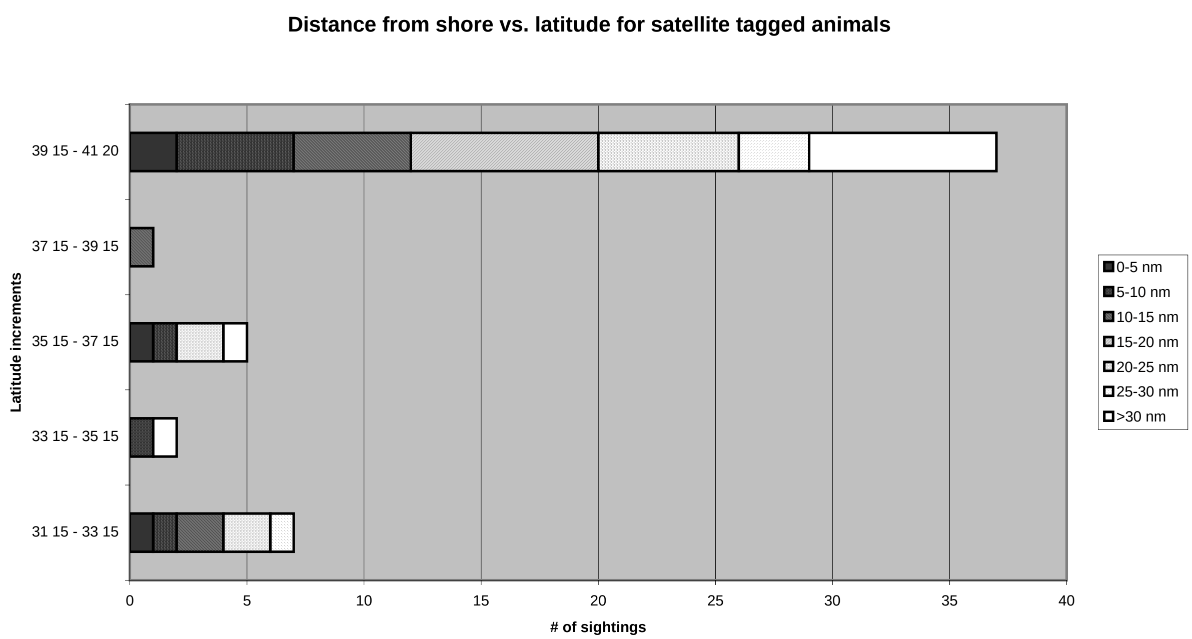


Table 1 shows that over half of the satellite tag sightings are within 20 nm of the coast. However, if the data from the northern latitude increment were not included, since it appears to show a different pattern than the area to the south, this percentage would increase to 80%. It should be noted, however, that this is only represented by 15 tagged sightings of three females with calves south of the most northern latitude increment so the sample size is quite small.

Water depth

A graph showing water depths for each sighting broken down into 5 fathom increments shows the majority of sightings are within 5-10 fathoms of water with the second highest number of sightings in 0-5 fathoms of water (Figure 4). In Table 2, the percentage of total sightings found within each maximum depth increment shows that 93% of all sightings are within 25 fathoms of water and 80.5% of the sightings are within 15 fathoms of water.

Figure 4.

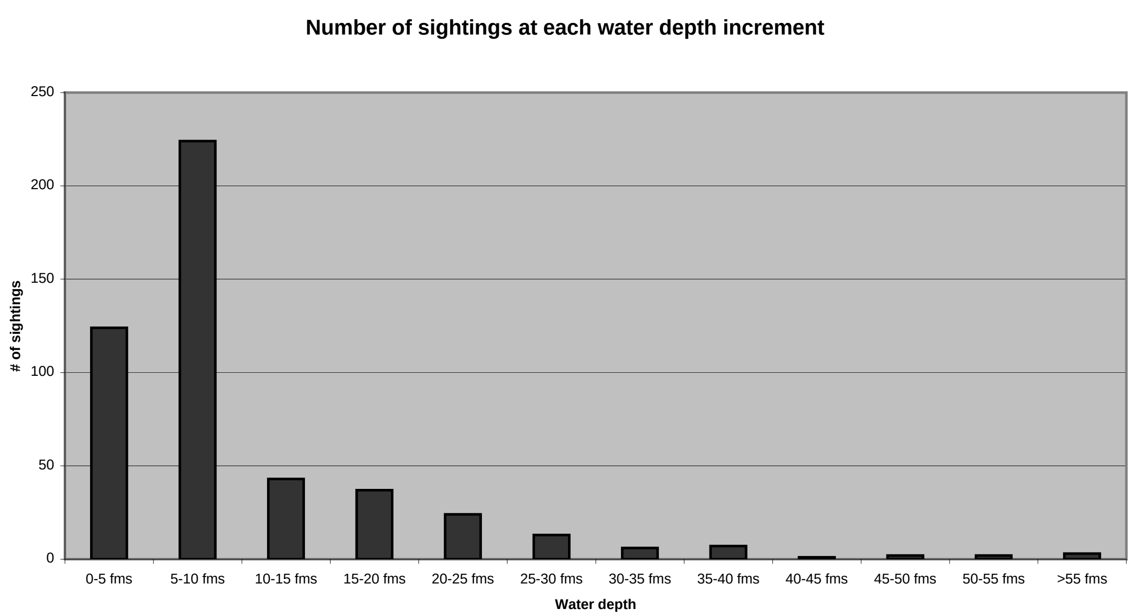

Number of sightings at each water depth increment
# of sightings
250
200
150
100
50
0
0-5 fms
5-10 fms
10-15 fms
15-20 fms
20-25 fms
25-30 fms
30-35 fms
35-40 fms
40-45 fms
45-50 fms
50-55 fms
>55 fms
Water depth

Table 2. Water depth range of all sightings and tagged animal sightings

Water depth range of sightings (in fathoms)	% of sightings within given water depth range	% of tagged sightings within water depth range
0-5 fms	25.5%	3.8%
0-10 fms	71.5%	17.3%
0-15 fms	80.5%	38.5%
0-20 fms	88.1%	53.8%
0-25 fms	93.0%	69.2%
0-30 fms	95.7%	84.6%
0-35 fms	96.9%	90.4%
0-40 fms	98.4%	94.2%
0-45 fms	98.6%	96.2%
0-50 fms	99.0%	98.1%
0-55 fms	99.4%	100%
0->55 fms	100%	

A comparison of water depths of tagged sightings shows that only 38.5% of sightings are within 15 fathoms and 69.2% are within 25 fathoms. Again, this could be partly attributable to the higher number of sightings in the northern extent. If the northernmost latitude increment is not included, 80% of the tagged sightings are within 15 fathoms. And again, this is reflected with a very small sample size.

Distance to ports

Table 3 lists the number of sightings within the 40 nm buffer placed around each port entrance and the cumulative percentage of sightings within 20 to 40 nm from the port entrance at 5 nm increments (see Series 2 plots).

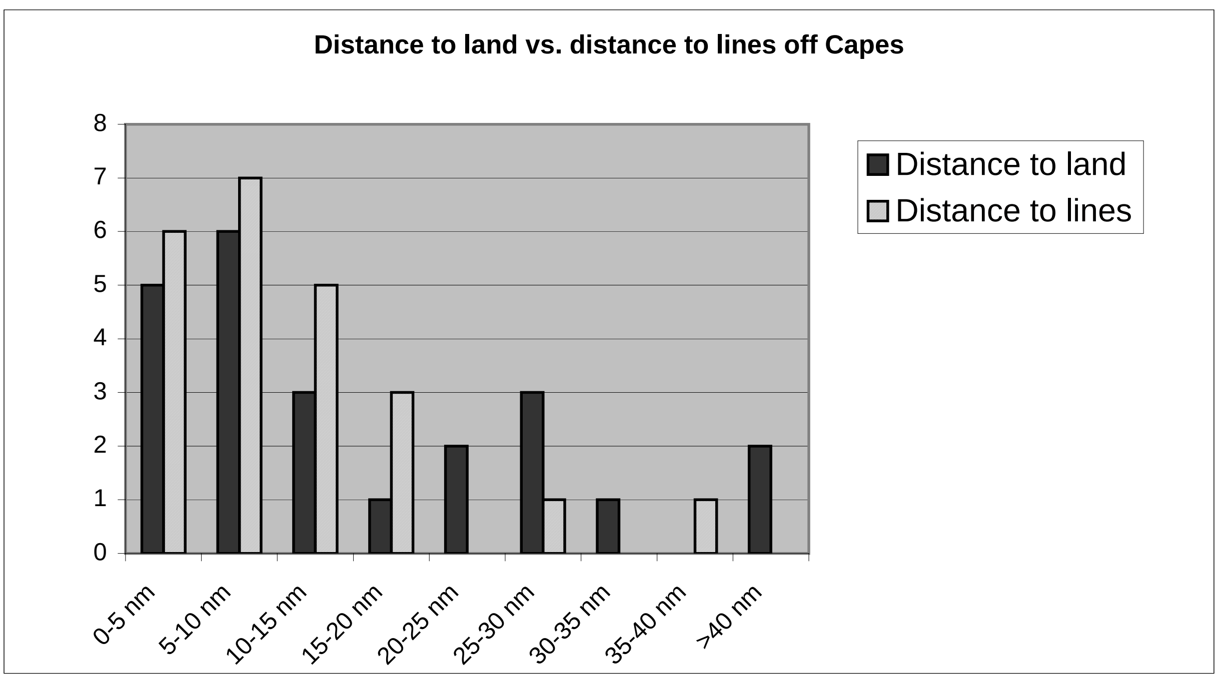
Table 3. Total number of sightings within 40 miles of port and % within each buffer.

Port entrance	# of sightings w/in 40 nm buffer	% of sightings from 0-20 nm	% from 0-25 nm	% from 0-30 nm	% from 0-35 nm	% from 0-40 nm
Providence/Buzzards Bay	18	56.6%	77.8%	94.4%	100%	
NY/NJ	9	11.1%	33.3%	55.6%	66.7%	100%
Delaware Bay	4	25.0%	25.0%	25.0%	75.0%	100%
Chesapeake Bay	9	33.3%	33.3%	77.8	100%	
Morehead City	17	88.2%	88.2%	94.1%	100%	
Wilmington	18	76.5%	76.5%	88.2%	88.9%	100%
Georgetown	17	35.3%	52.9%	70.6%	82.4%	100%
Charleston	19	47.4%	47.4%	63.2%	78.9%	100%
Savannah	102	49.0%	63.7%	78.4%	92.2%	100%
% range		11-88%	25-100%	25-100%	66-100%	

<u>Distance to lines</u>

Between Cape Hatteras and Cape Romain, the original distances to land and the distances to the line were compared by 5 nm increments (Figure 5). The plot shows that there were eight sightings beyond 20 nm of the coast. When the distance to the line was used, only two sightings were beyond 20 nm of the line.

Figure 5.



Sightings and effort by month

Plots 1-6 show sightings (both opportunistic and on effort) and survey effort by month. Each sighting is color coded by group size, satellite tagged, mother with a calf, or dead adult or calf. Since the calving season begins in November/December, reviewing the maps starting from September provides the reader with a seasonal cycle. In general, the data indicate that the vast majority of sightings are well within 50 nm of the coast even though effort extends much further offshore. Sightings are infrequently seen beyond 30 nm from shore except in the northern part of the range off of southern New England and Long Island.

To assess movement on a month by month basis, survey effort and sightings were categorized by light, moderate, and heavy for effort and none, few, some and many for sightings. The area was broken down in to three sub-areas – north of Cape Hatteras, south of Cape Hatteras and the coast of Georgia and categories ranked for each area to evaluate patterns of migration (Table 4). The data suggest that the number of sightings are not necessarily related to effort since months with heavy effort sometimes had few sightings. General patterns of animal movement can be seen when looking at this table and at the monthly plots. For north of Cape Hatteras, there seems to be a pulse of sightings in March and April with few sightings for nearly all months between May and October. For south of Cape Hatteras, a similar pattern seems evident with many sightings detected in March and April, with few to no sightings from May through October, and some sightings from November through February. Off the coast of Georgia, most sightings occurred from December through March with a noticeable decline in April. This coincides with departure of animals from the calving ground typically in March and the subsequent increase in sightings to the north as animals migrate northward.

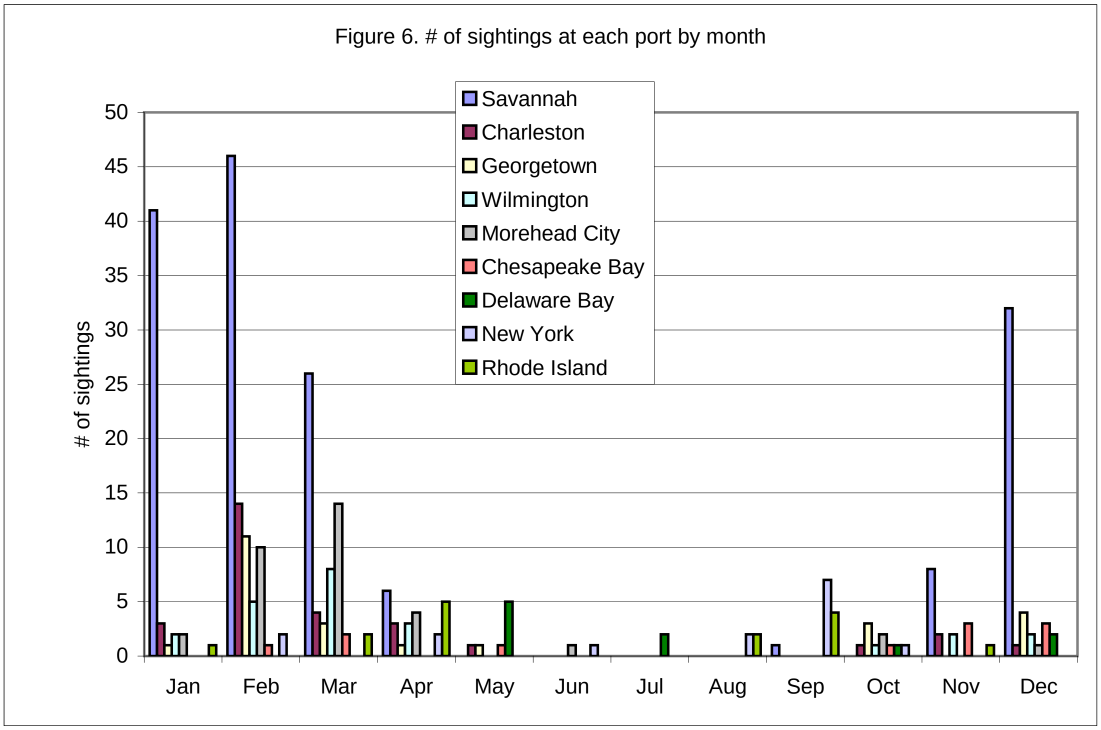
Table 4. Description of effort and sighting levels by geographic regions

AREA	EFFORT RATING	SIGHTING SUMMARY
North of Cape Hatteras		
Sep	heavy	few
Oct	heavy	few
Nov	moderate	some
Dec	moderate	some
Jan	light	some
Feb	light	some
Mar	moderate	many
Apr	moderate	many
May	moderate	few
Jun	moderate	few
Jul	moderate	few
Aug	moderate	some
South of Cape Hatteras (not including Georgia)		
Sep	light	few
Oct	light	some
Nov	light	some
Dec	moderate	some
Jan	moderate	some
Feb	moderate	many
Mar	heavy	many
Apr	light	many
May	light	few
June	light	few
July	light	none
Aug	light	none

From Savannah southward, effort was nonexistent in May through August, light in October and April, moderate in November and heavy from December through March. Sightings were nonexistent in October and May through August, few in April and September, some in November, and many in December through March.

Temporal movement through port areas

To assess whether movement of animals through certain port areas was seasonal, all sightings within 40 nm of each port entrance were broken down into month increments (Figure 6).



Savannah shows the highest frequency of sightings which may be partly attributable to survey effort. The peak time frame of presence in the area is December through March with limited sightings in November, April, and May. This peak use coincides with the calving season and suggests that calving females and others may cover a broader area than the presently designated critical habitat.

Sightings in the vicinity of Charleston extended from October through May with peak detections in February and March. This could coincide with the beginning of the departure of females from the calving ground.

Georgetown shows sightings for October and December through May with peak occurrence in December and February. This occurrence may represent movement in to and out of the high-use area to the south.

Occurrence in the vicinity of Wilmington is seen in October through April with peak sightings in March and February. This could also reflect movement of females with calves as they head north.

Morehead City shows the same pattern as Wilmington.

Sightings near Chesapeake Bay occur in October through December, February and March. One sighting in May was of a female and calf who had been in northern waters and came south to Chesapeake Bay and returned north. The slight peaks detected in November, December and March coincide with the migratory time frame.

In Delaware Bay there are very few sightings – one each in October, December, May and July. It is hard to see any pattern with so few sightings.

Off of New York, sightings have occurred in February, April, June, August and September. It should be noted that the peak shown in September is represented by one tagged female and her calf who did a round trip excursion from the Bay of Fundy to New Jersey in a six week period. Whether this is at all typical is not known. Otherwise, there seems to be no detectable pattern of movement past the port of New York.

Sightings off of Rhode Island (note these are sightings southward of a line extending from the west end of Marthas Vineyard to Montauk Point) have been detected in January, March, April, August, September and November. Similar to New York, the sightings in September are represented by the one tagged female. The slight increase in sightings in March and April may partly reflect migration of animals from the calving ground, however many of these sightings are not of mother calf pairs or animals seen earlier in the calving ground. Thus there may be other animals using this area during the spring months in some years.

Mortalities

Fourteen mortalities are reflected in these plots. These mortalities are reviewed here to look at time frame, cause of death and proximity to port entrances.

In January, three mortalities were documented – one was a ship struck adult male well south of Savannah, the second was a neonate near Charleston and the third was a juvenile off of Rhode Island. The cause of death of the juvenile was undetermined though it did have fishing gear wrapped around the tail.

Two mortalities were documented in February – a neonate just south of Savannah and a ship struck juvenile near the southern port entrance to New York.

In March, two mortalities were documented – a ship struck calf halfway between the entrances to Chesapeake and Delaware Bays, and a ship struck juvenile at the outer end of Long Island.

In April and May, no mortalities were documented.

In June, a ship struck calf was found on Long Island in near proximity to the northern lanes leading to New York.

In July, one mortality was detected in Rhode Island (see Rhode Island port map for location). The cause of death was due to entanglement.

No mortalities were detected in August and September.

In October, two mortalties were documented – one in New Jersey was due to entanglement. For the second one, just south of Chesapeake Bay, the cause of death could not be determined due to advanced decomposition.

In November, no mortaltities were detected.

Three mortalities were detected in December – one was a neonate on St Simons Island and the other two were sighted on the same day at the entrance to Chesapeake Bay. One of the two was shipstruck. The cause of death of the second was undetermined as the carcass was not retrieved.

DISCUSSION

The plots and analyses presented in this report show that the geographic extent of the migratory corridor for right whales can be fairly accurately described. The concern of nearshore effort bias does not seem to be warranted as both the satellite tag data and the effort data show that these animals seem to prefer the nearshore waters – 94% of all sightings and 80% of tagged animal sightings occurred within 30 nm of land. Despite extensive offshore effort depicted in the monthly plots, sightings of animals far offshore are very rare. In the future, sightings per unit of effort analyses should be carried out for effort data in this region to further quantify this apparent pattern. Water depth preference also seems to be towards shallower waters. 80% of all sightings were within 15 fathoms (90 feet) with 71% of all sightings within 10 fathoms (60 feet) of water.

The buffer zones placed around each port entrance indicate that a 20 nm buffer typically picks up less than half the sightings that pass the entrance. At 25 nm, over 50% of the sightings are included at five of the nine ports. At 30 nm, only one port (Delaware Bay with few sightings) has fewer than 50% of the sightings included. The other eight ports have between 55% and 94% of sightings within 30 nm. And at 35 nm the inclusion level is close to 100%.

The temporal movement of animals past each port does seem to reflect the general patterns of migration. However, this information is based on limited data for certain ports including New York, Delaware and Chesapeake Bays. The work presently underway by Russell Leaper of IFAW may allow for a more defined timeframe of movement past these ports based on departure from the southeast U.S., typical swim speeds, and distance from the calving ground to each port entrance.

The mortality data do show a link between shipstruck animals and proximity to shipping lanes and some correlation between deaths and timeframes of migration.

This study shows that the migratory corridor is limited in both geographic and temporal extent. Efforts to manage vessel traffic in this region can thus be based on more comprehensive data analyses than what previously existed.

REFERENCES CITED

Mate, B.R., Nieukirk, S.L., and Kraus, S.D. 1997. Satellite-monitored movements of the northern right whale. Journal of Wildlife Management 61: 1393-1405.